New Product

Engineer Assist™ Software: A knowledge-based system for the 90's

We are pleased to present Bently Nevada's latest development, Engineer Assist (EA) Software, an expert system for rotating machinery diagnostics. We have called the Software "Engineer Assist" because it is intended **to assist, not replace, the rotating equipment specialist**.

The software is indeed an expert system in that it simulates the thought process of a machinery expert. EA will produce reports of the existing malfunctions on a particular machine based on the data provided. But before any corrective action is taken on the machine, a qualified machinery specialist, with personal knowledge of the operational behavior of that particular unit, should review the report and make the final decision for action to be taken.

This software represents much of what Bently Nevada has learned about rotating machinery dynamics over the last 37 years. This article describes the EA Software and compares it to other machinery diagnostic expert systems on the market.

Automated data acquisition

Most of today's expert systems are "session-driven" in that the user must sit at the computer and answer questions prompted by the software. The user must input (via keyboard entry) all the machinery information needed by the software to perform its analysis. These inputs include such data as bearing types and clearances, rotor balance resonances (critical speeds), and other characteristics of the machine's design and process. Also, data measured on the machine (vibration amplitude, vibration frequency, process values, etc.) must be entered in numerical format.

Such sessions are time-consuming, error-prone and must be executed by someone quite knowledgeable of the machinery in question. The session takes so much time because there are typically tens, if not hundreds, of questions to be answered. Furthermore, the computer program user must be machinery-knowledgeable because some of the questions are subjective.

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EA requires a similar input of machinery design characteristics. There is a configuration program that is session-driven and requires the user to be machinery-knowledgeable. However, the configuration program does not require the input of measurement data in the form of numerical entry. Instead, EA receives this data in digital form, **computer-to-computer**, from our on-line computerized machinery monitoring system, Transient Data Manager™ (TDM).

Operation of the program is much less time-consuming because once the machinery configuration is loaded, no further data entry is required by the user. Multiple machinery analyses can then be performed with measurement data input coming directly from the TDM database. The program is less error-prone for the same reason. Except for the configuration session, a machinery specialist is not needed to operate the software. A technician can easily perform a machinery analysis (called a machinery "audit" by the EA Software).

A complete machinery information database

Most of today's machinery analysis expert systems produce their results from a database. In fact, **most systems use only two types of data**, overall vibration amplitude and vibration frequency. These programs are not much more than computerized versions of the classical "symptom versus cause" charts that have been published for decades. Although vibration amplitude and frequency **are** key ingredients for any machinery analysis, considering **only** these two variables can be dangerously misleading! ***Too often, an incorrect diagnosis results from evaluating amplitude and frequency data alone.***

All vibration analysis charts attribute rotor unbalance as the primary cause of vibration at shaft rotative frequency (1X). This may be true for more than half of the situations where 1X is the predominant vibration, but EA machinery audits are based on **additional machinery behavior characteristics** to correctly identify the more subtle ►

causes of 1X vibration. These can include shaft bow, shaft cracks, etc.

In order to correctly diagnose these machinery faults, other data is needed. This data includes such characteristics as average shaft position within the bearing clearance, shaft slow roll vectors, and 1X and 2X vibration and phase lag angle. Rotor unbalance is certainly not the only cause of 1X vibration. For a particular machine, due to many different design and operational characteristics, rotor unbalance may not even be the **most common** cause of 1X vibration.

The essential types of data needed by our EA Software include:

- Vibration amplitude
- Vibration frequency
- Vibration form or shape (of the Timebase waveforms and shaft Orbits)
- Direction of Orbit precession within the bearing clearance
- Phase lag angle
- Shaft Centerline position
- Machinery process data values

Converting machinery data into information

Machinery data is only an indicator of the malfunction(s) that may be present on a machine. To perform a complete and accurate analysis, some of the **data** must first be converted into **useful information**. An example is the data representing average shaft position within the radial bearing clearance. The data comes from the dc (average gap) output of radial XY proximity probes.

When a horizontal machine is stopped, the rotor can be assumed to be at the bottom center of its bearings. At this time, dc gap voltage readings are documented. When the machine is at normal operating conditions, another set of dc voltages are recorded. Comparing these readings indicates the radial movement of the shaft due to the formation of the oil wedge and support film. The "at speed" data represents the average position of the shaft within the radial bearing clearance.

Most expert systems do not even consider this data. EA Software not only considers it, but also uses the data to define other characteristics of the rotor/bearing system. The program relates the average shaft position to the bearing centerline and calculates the **shaft position angle** (sometimes called "attitude angle"). It is known that certain bearing designs will produce a range of "normal" shaft position angles.

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Shaft position data compared to the geometric bearing center and radial bearing clearance is also used to calculate the shaft-to-bearing **eccentricity ratio.** This is the ratio of the distance from the shaft center to the bearing center as compared to the radial bearing clearance. This ratio is a numerical value from zero (where the shaft and bearing centers are collinear) to one (where the shaft is in contact with the bearing surface).

Shaft position angle and eccentricity ratio are indicators of the **degree of bearing stability.** A normal position angle and high eccentricity ratio indicate a stable bearing. A high position angle and low eccentricity ratio indicate a bearing that is susceptible to (or one already the victim of) fluid-induced instability.

Individual knowledge bases and rules can be added by the user

EA Software offers an optional Utility Module, a feature that allows the user to input specific Rules and Knowledge Bases unique to the particular machine being audited. Bently Nevada EA Rules and Knowledge Bases are those common to most malfunctions on most machinery designs. However, based on the operational history and behavior characteristics of a particular machine, **a good machinery specialist will develop a unique set of rules to more completely analyze that machine.**

The user can add such rules to the EA audit process and include that analysis as part of the Audit Report. The utility module can be invoked at any time during the normal EA audit. User rules can be applied to a particular bearing location, machine case, or complete machine train. The final Audit Report will include the results from the standard EA audit, in addition to the results from the user rule-based audit.

Engineer Assist™ as a training tool

The EA program is an excellent training tool, particularly for new personnel. The program includes extensive tutorial text to explain how a particular conclusion was reached. Once a machine audit is completed, the user can review information to see how the analysis was made. Particular machine malfunctions can be reviewed to gain an understanding of the thought processes used in the audit.

Remote machinery diagnosis

A remote communications package is included with the EA program. One person with EA Software at the machinery site (the TDM site) can perform the data extraction routine, collecting the necessary data from the TDM System. That data can then be sent via telephone modem to a remote site where another person can conduct the actual EA audit. This function supports a basic objective of Bently Nevada to "move data, not people."

Summary

We are very proud of this new software. Not only does it represent much of what we have learned about rotating machinery over the past 37 years, it is also a well-designed program with features that result in direct, measurable benefits to the user. For more information on our Engineer Assist™ Software, please contact your nearest Bently Nevada sales representative. ■